Running head: The Origin and Evolution of Cardiopulmonary Resuscitation.

The Origin and Evolution of Cardiopulmonary Resuscitation

Michael L. Wallace

Central Jackson County Fire Protection District

Blue Springs, Missouri

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: ____________________________

Abstract

The problem is the practice of cardiopulmonary resuscitation among rescuers (at all levels) is fraught with inconsistencies caused by a gap between what are established standards of care, and what should be based on evidence based medicine and outcome data. Because of this, inconsistent treatment and inconsistent outcomes of patients in cardiopulmonary arrest are seen.

Historical research was utilized to answer the following research questions:

(1) What are the origins of cardiopulmonary resuscitation and how has cardiopulmonary resuscitation evolved over time up to current recommendations?

(2) As it relates to the human body, how does cardiopulmonary resuscitation work physiologically?

(3) What guidelines exist that define how cardiac arrest resuscitation efforts, including CPR, should be performed?

(4) What other techniques or modifications are being used in treatment of cardiac arrest?

Research was conducted by review of pertinent literature with an emphasis on the history of cardiopulmonary resuscitation and the management of cardiac arrest. Historical data on cardiac arrest outcomes from the Central Jackson County Fire Protection

District were analyzed and compared to the same data from the City of Kansas City, Missouri.

Recommendations were made as a result of this historical research and in response to the problem statement. EMS agencies must challenge themselves to be open to other alternatives to resuscitation (and medicine in general) that are based on solid outcome data in support of evidence based medicine.

Opportunities exist within our communities to provide education on CPR, specifically hands only CPR. EMS agencies should be proactive in our communities and take the lead in organizing hands only CPR and other health issues like heart disease and stroke classes for the communities they serve.

Table of Contents

INTRODUCTION

The problem is the practice of cardiopulmonary resuscitation among rescuers (at all levels) is fraught with inconsistencies caused by a gap between what are established standards of care, and what should be based on evidence based medicine and outcome data. Because of this, inconsistent treatment and inconsistent outcomes of patients in cardiopulmonary arrest are seen.

The purpose of this research project is to explore the history and development of cardiopulmonary resuscitation which will provide a sound educational tool that will improve the uniformity of treatment, and provide practitioners with a sound foundation for the development of new techniques for adult patients experiencing cardiopulmonary resuscitation.

The historical research method will be utilized to answer the following research questions:

(1) What are the origins of cardiopulmonary resuscitation and how has cardiopulmonary resuscitation evolved over time up to current recommendations?

(2) As it relates to the human body, how does cardiopulmonary resuscitation work physiologically?

(3) What guidelines exist that define how cardiac arrest resuscitation efforts, including CPR, should be performed?

(4) What other techniques or modifications are being used in treatment of cardiac arrest?

Research was conducted by review of pertinent literature detailing the history of cardiopulmonary resuscitation and the management of cardiac arrest. Historical data on cardiac arrest outcomes from the Central Jackson County Fire Protection District were analyzed and compared to the same data from the City of Kansas City, Missouri.

BACKGROUND AND SIGNIFICANCE

Out-of-hospital cardiac arrest (OHCA) is the leading cause of death among adults in the United States according to the Cardiac Arrest Registry to Enhance Survival (CARES) (CARES, 2010). Although there is a wide variation in the reported incidence and outcome data for OHCA, but is estimated that approximately 400,000 OHCA deaths occur every year in the United States and Western countries.

The American Heart Association acknowledges there is a wide variation in the reporting of OHCA data, it estimates that there are approximately 164,600 OHCA in the United States each year (American Heart Association, 2010).

Webster’s dictionary defines cardiac arrest as a “temporary or permanent cessation of the heartbeat.” Cardiac arrest can be caused by many reasons, however often times it is caused by a heart attack, and enlarged heart, congenital heart defects, or electrical problems of the heart. Many of these deaths are due to a fatal heart rhythm called ventricular fibrillation (Mayo Clinic, 2010).

The CARES program is a collaborative effort of the Centers for Disease Control and Prevention, the American Heart Association, and the Emory University Department for Emergency Medicine. The Mission of the CARES program is to reduce the death rate from heart disease and stroke by 25% by the year 2010. CARES has made a priority to create a model national registry to accurately measure the progress in OHCA (CARES, 2010).

According to CARES, there are approximately 35 communities in the United States that actively monitor and report their survival rates from OHCA. Of the communities that actively report data, it is estimated that the survival from OHCA ranges from 2% to 35% when ventricular fibrillation was noted as the presenting rhythm (CARES, 2010). According to the AHA, the median reported survival to discharge from OHCA is 6.4% (American Heart Association, 2010).

In a report titled “Out-of-hospital Cardiac Arrest Survival Rate Unchanged in 30 years” by the Occupational Health & Safety (2010), the chance of surviving an OHCA has not improved since the 1950’s. An analysis conducted by the University of Michigan Health System showed that only 7.6% of people survive an OHCA which has not changed in almost 30 years. In a study conducted by the University of Michigan Health System, researchers looked at data from 79 studies published internationally between January 1950 and August 2008. In the study, data from 142,740 patients with OHCA was analyzed. Here is what the researchers found:

1. Of more than 140,000 patients, only 23.8% survived to hospital admission, and 7.6%, or about one in 10 people lived to be discharged from the hospital.
2. Cardiac arrest victims who received CPR from a bystander or an emergency medical services provider, and those who had a shockable heart rhythm, referred to as ventricular fibrillation, were more likely to survive.
3. The strongest predictor of survival was a return of spontaneous circulation, meaning a pulse was restored at the scene. Among them, 15.5% (in low-performing systems) to 33.6% (in high-performing EMS systems) survived.

We can see that the findings of the study conducted by the University of Michigan coincide with data collected by CARES respectively when it comes to survival from OHCA.

Where you live can have an impact on whether you are resuscitated or not following a cardiac arrest. For example, if you reside in Seattle, Washington and you experience a cardiac arrest, you have a 30% chance of being resuscitated and discharged from the hospital. However, if you reside in New York City, you have a one to two percent chance of survival (American Heart Association, 2010).

We have looked at national in international data, but how are we doing at the local level? In 2009, the Central Jackson County Fire Protection District (CJCFPD) responded to 76 calls for service for which the nature of the calls were cardiac arrest. Statistics gathered of OHCA fell into two categories: first, cardiac arrest where upon arrival the patient was triaged as an “obvious death”, or second, determined to be “cardiac arrest.” Those patients who were determined to be “cardiac arrest” were candidates considered for resuscitation.

For the year 2009, CJCFPD triaged 37 patients as being in the “obvious death” category where resuscitation was not considered and not attempted. Thirty nine patients however were determined to be candidates for resuscitation. Six of the 39 patients determined to be candidates for resuscitation were not resuscitated for various reasons; valid Do Not Resuscitate (DNR), three cases involved major trauma including two gunshot wounds to the head, and one multi-systems trauma patient. In each of these cases, Medical Control was contacted and no resuscitation orders were received. The remaining 33 patients received full resuscitation attempts by EMS personnel.

Patients presenting in cardiac arrest in which resuscitation was attempted presented in three initial cardiac rhythms for EMS (Figure 1). In 18 of the 33 patients, the initial presenting rhythm on ECG was Asystole (as verified in more than one lead). In nine patients, the initial presenting rhythm was Pulse Electrical Activity (PEA) in which an electrical complex was presenting on the ECG however no physical contraction of the heart could be detected. The remaining seven patients presented with ventricular fibrillation on the ECG.

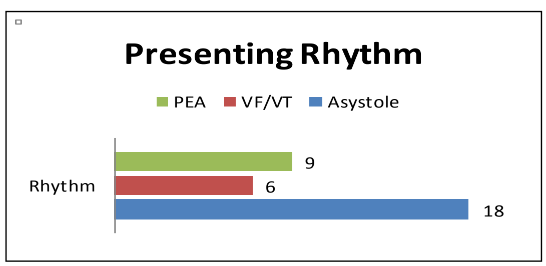


Figure 1: Initial presenting rhythms

Of the 33 patients where resuscitation was attempted, twenty five were not successfully resuscitated. These patients were pronounced dead either at the hospital following continued resuscitation or in the field with termination of efforts by EMS. Six patients were successfully resuscitated by EMS crews and presented to the hospital with a return of spontaneous circulation (ROSC). Of the six patients resuscitated by EMS personnel, five presented with ventricular fibrillation and one in PEA on the cardiac monitor. Two patients had a ROSC while the emergency room (Figure 2).

Figure 2: ROSC

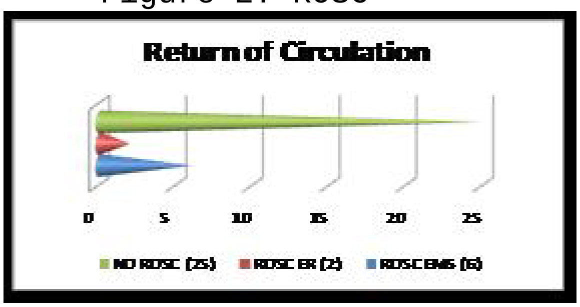
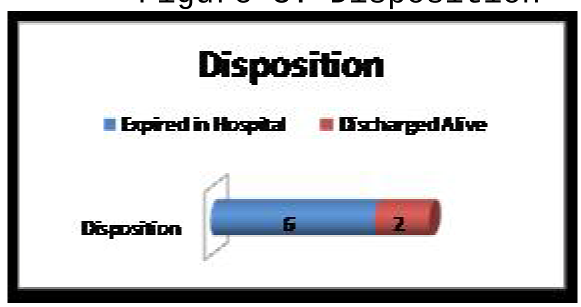


Figure 3: Disposition



Interestingly, of the eighteen patients who presented with Asystole on the ECG and resuscitation was attempted, none of those patients had a return of spontaneous circulation and were pronounced dead shortly after arriving at the hospital.

As ROSC is the measure of successful resuscitation, the ultimate goal is to have each patient walk out of the hospital. For the year of 2009, CJCFPD had two patients meet this criteria and walk out of the hospital (Figure 3). So how does the success of CJCFPD compare to the national ROSC rates? For the year 2009, CJCFPD has a ROSC rate of 24% which is based on all rhythm presentations and 6% resuscitation to hospital discharge.

For a local comparison, the City of Kansas City, Missouri (KCMO) published their annual cardiac arrest data from 09/08 through 08/09. During this time, KCMO reported a ROSC rate of 28% and 20% resuscitation to hospital discharge.

Survival from OHCA is highly impacted on where you live. Whether you live in Seattle and enjoy a 30 percent OHCA survival, or you live in New York City where the OHCA resuscitation rate is only 1-2 percent, the obvious question comes to mind, what are they doing different? What is KCMO doing different from CJCFPD for them to have higher OHCA resuscitation to hospital discharge rates?

The Department of Homeland Security's United States Fire Administration (USFA) (National Fire Academy, 2008) has established five strategic objectives that serve to provide guidance and to help identify priorities for initiatives at all levels. The five operational objectives are:

1. Reduce the loss of life from fire in the age group 14 years old and below.
2. Reduce the loss of life from fire in the age group 65 years old and above.
3. Reduce the loss of life from fire of firefighters.

4. To promote within communities a comprehensive, multi-hazard risk-reduction plan led by fire service organization.
5. To respond appropriately in a timely manner to emerging issues.

Understanding why OHCA ROSC and survival to hospital discharge varies significantly from community to community must be a high priority for all EMS agencies. From a customer service prospective, are we meeting the expectations and needs of the communities served when it comes to OHCA?

The author believes this issue falls well within all of the five USFA operational objectives. The author believes that researching this issue is responding appropriately in a timely manner to a significant emerging issue. Additionally, the number one cause of firefighter deaths is due to heart attack and stroke. Many firefighter cardiac arrests occur on the fire ground or during more relaxing times in the fire house. Fire fatalities involving the young and old often involve OHCA resuscitation efforts.

It is the responsibility of all fire service organizations to develop comprehensive, multi-hazard risk-reduction plans which should include public education and awareness to include heart attack, stroke, and OHCA awareness.

Literature Review

Cardiac arrest can be defined as the cessation of cardiac function with the patient displaying no pulse, no breathing, and is unresponsive. Cardiac arrest also occurs when the heart is not contracting well enough to generate pulses (Mistovich & Karren, 2010). Cardiac arrest remains a substantial public health issue and is a leading cause of death in the United States. According to the American Heart Association, each year in the United States and Canada there is approximately 350,000 cardiac arrests that receive resuscitation attempts (The American Heart Association, 2010).

In order to fully understand what is occurring in the body when a person goes into cardiac arrest, we must first review some very basic human physiology. And there is no better place to begin than at the cellular level. The basic living unit of the body is the cell. The human body is made up of approximately 75 trillion cells whose only job is to create energy, reproduce, and provide a specific function. Cells make up tissues, tissues make up organs, and organs make up organ systems. Examples of organ systems include the cardiovascular system, the renal system, and the nervous system (Guyton, 1982).

Cells live and grow by a process known as cellular metabolism. According to Websters dictionary, metabolism is defined as “the chemical changes in living cells by which energy is provided for vital processes and activites.” In order for cellular metabolism to occur, proper concentrations of oxygen, glucose, amino acids, and fatty substances must be available in the cells internal environment(Guyton, 1982).

Metabolism involves three phases, digestion, glycolysis, and the citric acid cycle. In the digestion phase, large molecules are broken down into smaller useable units outside of the cell. Phase two of metabolism involves the splitting of glucose also known as glycolysis. In glycolosis, pyruvic acid and a small amount of energy are created. The energy created is used to continue to process of metabolism into the final phase. The final phase of cellular metabolism is known as the citric acid phase. In this phase, pyruvic acid with the assistance of oxygen, is further metabolized into cellular energy. Most of the cells energy is created in this final phase. As with any form of metabolism, by-products are created and must be removed from the cell. Carbon dioxide is created in cellular metabolism and must be removed from within the cell(Huether & McCance, 2004).

Adenosine Triphosphate or ATP is an energy carrying molecule that stores the energy created. ATP can also transfer stored energy to other cells. As mentioned previously, oxygen is critical to cellular metabolism. If oxygen is not available, the cell cannot enter into the final stage of metabolism. When this occurs, the pyruvic acid which resides within the cell is converted to lactic acid and released out of the cell. This is also known as anaerobic metabolism. A chain reaction of cellular dysfunction begins to occur in the cell and within a short period of time, the cell begin to die. This process is known as apoptosis. If oxygen can be re-introduced to the cell in short order, the cell will quickly convert the lactic acid back into pyruvic acid or glucose(Huether & McCance, 2004).

When a person experiences cardiac arrest, the heart stops pumping oxygenated blood around the body. When this occurs, the cells begin accumulating pyruvic acid, lactic acid, and carbon dioxide leading to cellular dysfunction and death.

In cardiac arrest, time is of the essence. As soon as the heart stops pumping, the clock begins to tick. If a person can be resuscitated within the first few minutes of the arrest, then the likelihood of a good outcome is significantly greater (The American Heart Association, 2010).

Organs such as the heart and the brain are extremely sensitive to the lack of oxygen caused by cardiac arrest. In fact, irreversible damage to the brain may begin in as little as four minutes. Whereas the brain and heart are very sensitive to the lack of perfusion, other cells of the body are not. Skeletal muscle cells for example, can be deprived of oxygen for a much longer period of time (Mistovich & Karren, 2010).

Despite the best efforts of researchers in the area of cardiac arrest and other advances in medicine, resuscitation rates of cardiac arrest patients have not increased, rather they remain essentially unchanged. Although there are a few different causes of cardiac arrest, many deaths are due to a fatal heart rhythm called ventricular fibrillation. In ventricular fibrillation, the heart cells are all firing in an uncoordinated manner. Because of this, the ventricles of the heart are unable to contract and move blood out of the heart. Treatment for ventricular defibrillation is immediate defibrillation (The American Heart Association, 2010).

Recent science has given us a better understand of what actually is occurring to heart cells the moment a person goes into cardiac arrest. There are three phases a patient goes through when suffering a cardiac arrest. These phases are the electrical phase, the circulatory phase, and the metabolic phase (Mistovich & Karren, 2010).

The electrical phase begins the moment the heart stops and ends within four to six minutes of the cardiac arrest. Heart cells have an adequate supply of oxygen and glucose needed for metabolism and cell wall integrity is preserved, essentially functioning as normal. During the electrical phase, the cell is still producing energy, and has stores of the high energy molecule ATP. A very common presentation on the electrocardiogram (ECG) is ventricular fibrillation. Evidence shows us that while the heart is in the earliest part of the electrical phase of cardiac arrest, it responds very well to the delivery of electrical energy or defibrillation. Additionally, time to defibrillation clearly shows a correlation to the chance of resuscitation (The American Heart Association, 2010).

The second phase is the circulatory phase which begins at approximately four to six minutes and lasting through ten minutes. This phase has also been referred to as the perfusion phase (Mistovich & Karren, 2010). During the circulatory phase, the oxygen stores have been depleted and the cell begins to shift to anaerobic metabolism. If defibrillation is performed in this phase, often times it is lethal (The American Heart Association, 2010).

The final phase is the metabolic phase. This phase begins approximately ten minutes after the heart has stopped pumping. In this phase, the heart cells have been starved of oxygen and glucose, and have accumulated large amounts of acid inside of the cell. Additionally, the membranes of the cells are beginning to break down allowing materials, mainly sodium and water, to flow into the cell causing the cell to swell and burst. Prognosis for survival of a patient in this phase of cardiac arrest is poor (The American Heart Association, 2010).

Procedures

The research method utilized for this applied research project was historical in nature. The author conducted an extensive literature search, reviewed current department medical protocol, and compared annual cardiac arrest data between CJCFPD and City of Kansas City, Missouri.

The literature search resulted in research being conducted through the review of textbooks, periodicals, journals and online articles. A limited online search at the National Fire Academy's Learning Resource Center was conducted for previous Applied Research Projects (ARP) on the topic of cardiac arrest and resuscitation. Although several potential resources were found, none provided the depth or breadth on the specific topic of the origins and evolution cardiopulmonary resuscitation from a historical perspective. The author believes that sufficient literature was available to be reviewed without the ARP reference.

A review of the 2009 Cardiac Arrest Annual Report from CJCFPD was used in comparison with the City of Kansas City, Missouri same year cardiac arrest data. This comparison was made to emphasize the difference in cardiac arrest resuscitation rates between an area department.

Results

The following are the findings for the original research questions presented in this research project:

(1) What are the origins of cardiopulmonary resuscitation and how has cardiopulmonary resuscitation evolved?

One of the earliest accounts describing resuscitation was occurred around 896 BC and was recorded in the bible. It was written: “…And he went up and lay upon the child, and put his mouth upon his mouth and his eyes upon his eyes, and his hands upon his hands, and he stretched himself upon the child, and the flesh of the child waxed warm” (Bible, 2 Kings, iv. 34).

Very early in history, the natural body heat of a person was associated with life. In death, the body becomes cold and was associated with death. In the early ages the heat method of resuscitation was used. In order to prevent death, active warming of the body was done with the use of hot ashes, hot water, and burning excrement in an order to restore life (TexasOnSite CPR, 2010).

Another method of resuscitation also recorded in the early ages was the flagellation method. When a person experienced death, the body would be whipped in order to stimulate life. The heat and flagellation methods of resuscitation where used up until the 1500's (TexasOnSite CPR, 2010).

Around 1530, the bellows method of resuscitation was utilized. In the bellows method, hot air was blown into the mouth of a victim's mouth using a fireplace bellow. This practice was based on the knowledge that when we exhale air from the lungs, it is warm. The thought at time was to replace warm air with the warm air of a fireplace using a bellow. The practice of the bellows method did produce chest rise in some victims, but not in all. At the time, the anatomy of the respiratory system was not known so practitioners were not aware of the need to "open" the airway to facilitate the flow of air in some victims. The bellows method also introduced the concept of positive pressure ventilation and has been referenced historically as giving thought to current day bag valve devices. The bellows method of resuscitation was utilized for the next 300 years (TexasOnSite CPR, 2010).

Around 1711, the fumigation method of resuscitation was developed as an alternative to the bellows method. To perform this technique, smoke would be blown into an animal bladder and then the smoke would be introduced into the rectum. The fumigation method was used, although with poor results, for the next 100 years until the practice was abandoned around 1811(TexasOnSite CPR, 2010).

In the 1700's the leading cause of death were deaths caused by drowning. In response to these drowning deaths, society began to organize more efforts to resuscitation and organized groups were formed. Organizations like the Dutch Society for Recovery of Drowned Persons and the Royal Humane Society of England were formed.

In 1767, the Dutch Society for Recovery of Drowned persons made the following recommendations for the resuscitation of a drowning victim:

1. Warming the victim by lighting a fire near the victim, burying him in warm ash, placing the body in a warm bath, or placing in bed with one or two volunteers;
2. Removing swallowed or aspirated water by positioning the victims head lower than his feet and applying pressure to the abdomen;
3. Stimulation of the victim, especially the lungs, stomach and intestines by smoke fumigation;
4. Restoring breathing with a bellows;
5. Bloodletting.

In 1770, the inversion method of resuscitation began to be utilized for the resuscitation of drowning victims. This method had been utilized by the Egyptians over 3,500 years before and was a very popular method in Europe. This practice involved a victim being hung by his feet and released to the ground in a repetitious cycle. It was the belief that when the victim was hanging upside down, the pressure generated would force air out of the lungs. When a victim is released to the ground, the pressure change would allow for air to be drawn back into the lungs (TexasOnSite CPR, 2010).

A few years later, in 1773 the barrel method was developed. In this method, a victim is placed onto a large wine barrel and rolled back and forth in an attempt to force air in and out of the lungs.

In 1812, horses were used as a way to facilitate the resuscitation of drowning victims on American beaches. A lifeguard would remove a drowning victim from the water and immediately place the victim onto the horse. The horse would then be “trotted” up and down the beach causing the body to bounce up and down on the horse. It was believed that this trotting action caused the chest to allow for compression and relaxation of the heart. In 1815, this practice was stopped because of pressure by the Citizens for Clean Beaches (TexasOnSite CPR, 2010).

Beginning around 1856, the priority of ventilation was replaced by a new focus, maintaining temperature. Marshall Hall, an English physiologist, began to challenge previous resuscitation practices including those viewed by the Dutch. Hall believed that ventilation without a warming process was detrimental to the victim. He also argued that clean air was better for victims and highly discouraged the use of the bellows technique. But Hall also realized something that would change the concept of resuscitation to this day, Hall realized when you place a victim on their back, the tongue will fall to the back of the throat blocking the airway passages. It was because of this finding, Hall developed the roll method of resuscitation. Hall argued that if you place a victim face down and you rolled them onto their side, then back to the face down position and you continued this cycle 16 times, it will facilitate ventilation without the concerns of the tongue blocking the airway. The Royal Humane Society was so impressed by the increase in movement in and out of the lungs; they adopted it as the official resuscitation method (TexasOnSite CPR, 2010).

In 1891, the first external cardiac compressions were documented. Dr. Friedrich Maass performed external cardiac compressions on a teenager for 60 minutes. The teenager was successfully resuscitated and with amazement to the medical community, had normal mental function. Despite the work performed by Dr. Maass, it was forgotten for many years. (Cooper, MD, & Cooper, 2006)

Other forms of resuscitation were being practiced around the world. Some of these involved the stretching of the rectum, vigorously rubbing the body, whipping, tickling with feathers, and the waving of strong salts under the victim’s nose. But in 1892, perhaps one of the most bazaar of practices was recommended, tongue stretching. This practice involved holding the victim’s mouth open and violently pulling the tongue rhythmically (TexasOnSite CPR, 2010).

Dr. James Elam is considered to be the father of modern day mouth to mouth ventilation; however history clearly shows us that Dr. Peter Safar also deserves this title as well. Doctors Elam and Safar, both anesthesiologists, were the first to prove that expired air was sufficient to maintain adequate oxygen levels in the blood of a victim in cardiac arrest. Dr. Safar performed experiments where human volunteers (Baltimore City Firefighters) were paralyzed with medications and then administered mouth to mouth ventilation. The results were profound. Dr. Safar found that exhaled air from mouth to mouth could provide enough oxygen during resuscitation efforts (Sands & Bacon, 1998).

Then in 1956, thanks to the work of Dr. Elam and his colleague Dr. Peter Safar, modern day mouth to mouth ventilation was developed. Additionally, Dr. Elam and Dr. Safar developed the “A” or airway and “B” or breathing steps in CPR. In the “A” step or airway, the airway is positioned in a way that the tongue is lifted from the back of the throat and allowing for the flow of air. Step “B” or the breathing step was to determine if the victim was breathing or not. It was important to allow for a few seconds to determine the absence of breath. If the victim was not breathing, then mouth to mouth ventilation was recommended (Mitka, 2003).

In 1957, the United States military officially adopted their method of mouth to mouth ventilation. Dr. Elam went on to author the instructional book entitled Rescue Breathing and later produced films demonstrating mouth to mouth ventilation (Sands & Bacon, 1998).

Dr. Safar continued his research developing the final “C” or circulation step of CPR with the development of cardiac compressions. In 1957, Dr. Safar authored the book ABC of Resuscitation which established a basis for CPR training. The

ABC concept of resuscitation was later adopted by the American Heart Association (Mitka, 2003).

A few years later, in 1960, Dr. W.B. Kouwenhoven began to research more into how external cardiac compressions work rather than on how to perform the compressions. He began experimenting with dogs, inducing them into ventricular fibrillation, and performing external cardiac compressions. Dr. Kouwenhoven measured the blood flow in the dogs with and without chest compressions, and how the compressions affected the underlying cardiac arrest rhythm of ventricular fibrillation. The results were astounding. Dr. Kouwenhoven's research revealed that the longer the compressions were performed, the better the blood flow. Additionally, Dr. Kouwenhoven showed that the longer chest compressions are performed, the longer the victim could remain in ventricular fibrillation. This would ultimately allow the victim to be defibrillated.

The 1970's proved to be a decade of public campaigns to teach the American population cardiopulmonary resuscitation or CPR. In 1972, Leonard Cobb held the first mass CPR class in Seattle, Washington where over 100,000 people were trained in CPR in only two years. In 1973, the American Red Cross and the American Heart Association became involved in endorsing and teaching CPR. The American Heart Association is recognized as a leader in resuscitation, and through the Emergency Cardiac Care or ECC arm of the American Heart Association, they establish standards of care that are recognized nationally (The American Heart Association, 2010).

(2) As it relates to the human body, how does cardiopulmonary resuscitation work physiologically?

How CPR works is certainly something that has been explored and debated since the practice of resuscitation began. Over the years, hypotheses have been developed but up until recent years, they have only been theories and medical conjecture. CPR is often portrayed to be highly effective in the movies and television, but reality shows us it is not. The New England Journal of Medicine in 1996 published a study illustrating that CPR was successful in 75% of cardiac arrest cases portrayed in the television and the movies (Texas OnSite CPR, 2010). The real survival rate according to the American Heart Association is six percent (The American Heart Association, 2010).

In order to understand how CPR works, we must first review some of the basic concepts of the circulatory and respiratory systems. The human cardiovascular system can be thought of as a closed fluid system that consists of some very important and interdependent anatomy. The heart, which can also be thought of as a pump, is a four chambered muscle that consists of two atria and two ventricles. Separating the various chambers of the heart are valves. It is the function of the valves to facilitate the blood flow through the heart to move in only one direction. The right side of the heart, also referred to as the venous side of the heart, is considered a low pressure pump. Flow into the right side of the heart or the right atrium is passive and is based on low pre-load pressures. The term pre-load refers to the available blood which is located in the venous side of the circulatory system. As blood enters the right side of the heart into the atrium, it passively drains into the right ventricle. Just as the ventricle becomes full, a sudden contraction of the atrium forces a small amount of blood into the ventricle causing the ventricular wall to stretch causing a rubber band type contraction when the ventricular muscle contracts. This contraction forces the pulmonic valve open allowing blood to enter the pulmonary artery (Guyton, 1982).

After blood passes through the pulmonary system or lungs, it re-enters the heart through the pulmonary vein and begins to fill the left atrium. Blood flow, much like on the right side, passively enters the left ventricle until such time it receives its atrial contraction from the left atrium (which is at the same time as the right). The atrial contraction causes a small amount of blood to be forces into the left ventricle causing the left ventricle to stretch. When the left ventricle contracts, at the same time as the right, the stretch causes the left ventricle to snap forcing the aortic valve open blood flows out into the arterial side of the circulatory system (Guyton, 1982).

The circulatory system consists of veins, venules, arteries, arterioles, and capillaries. When comparing veins and arteries, arteries are very thick and generally have three layers. The middle layer of the artery is also known as the smooth muscle layer. The smooth muscle layer plays a very important role in the regulation of blood pressure. Arteries have the ability for contract and dilate therefore regulating the pressure in the system (Guyton, 1982).

Veins on the other hand are significantly thinner but also have a smooth muscle component. Veins are different from arteries in that they cannot constrict in order to maintain blood pressure; this is exclusively done on the arterial side. Veins do share a common characteristic with arteries in that they have the ability to dilate. Dilation of the system is done passively and requires no energy. Medications such as nitroglycerin cause dilation of the veins are well as the arteries (Guyton, 1982).

Pressure within the circulatory system is vitally important. Without an adequate pressure, organs such as the heart, brain, and the kidneys cannot get the blood they need. As already mentioned earlier in this paper, arteries have the ability to constrict thus regulating pressures in the circulatory system adequate. This process is also known as auto-regulation. A very important concept to understand here is when a person goes into cardiac arrest, the circulatory system will dilate causing the pressures in the circulatory system to drop significantly (Guyton, 1982).

As pressure is important, so is the path in which the blood flows. Much like the heart valves facilitate blood flow in one direction, the circulatory system also has mechanisms to do the same. As blood flow leaves the left ventricle, it is facilitated through the arterial system with the assistance of the smooth muscle. The arteries contract in small sections and in an organized manner to facilitate the blood flow in one direction. Because the veins have much lower pressure, blood flow has more of an opportunity to pool or move more sluggishly through the venous system. Veins unlike arteries have valves located at various locations which prevent blood from moving backwards (Guyton, 1982).

Because the heart is a muscle, it also must have a way to receive oxygen and get rid of carbon dioxide. The heart is extremely sensitive to the lack of oxygen as compared to the other muscles in the body (Huether & McCance, 2004).

The heart receives its blood supply from the coronary arteries. The coronary arteries originate just above the aortic valve on the arterial side of the circulatory system. When the heart contracts, the aortic valve is opened and blood is forced out of the heart. This is also known as systole. As the pressure in the left ventricle falls lower than the pressure it is pumping against, the aortic pressure, then the aortic valve is shut causing a back pressure against the aortic valve. This is also known as diastole. As the diastole pressure against the aortic valve increases, blood is forces by back pressure into the coronary arteries and the heart receives its blood supply. The term coronary perfusion pressure is also used to describe this process. Because the heart receives its blood flow during the relaxation phase, adequate pressure in the circulatory system is critical. Without an adequate coronary perfusion pressure, the coronary arteries will not fill and the heart will receive no blood (Huether & McCance, 2004).

Coronary perfusion pressure and the return of spontaneous circulation following cardiac arrest are strongly linked. In a study conducted at Henry Ford Hospital in Detroit, Michigan, the coronary perfusion pressures of one hundred cardiac arrest patients were measured. Those victims who were resuscitated were associated with higher coronary perfusion pressures of 15 mmHg or more. Those who had pressures below 15 mmHg were not resuscitated (Paradis, Martin, Rivers, & Goetting, 1990).

Another study conducted by Dr. Karl Kern, et.al, at the Sarver Heart Institute in Tucson, Arizona showed the same correlation between coronary perfusion pressure and the ROSC of cardiac arrest patients. The study showed that patients who had a coronary perfusion pressure of less than 5 mmHg could not be resuscitated. In those patients who had coronary perfusion pressures of 15 mmHg were resuscitated but ultimately expired. However most noteworthy involved those patients whose coronary perfusion pressures were between 25 and 30 mmHg, those patients were not only resuscitated but many survived (Kern & Ewy, 1988).

The final component of the cardiovascular system is the blood. Since our cardiovascular system is a closed system, we have a set amount of blood available in the system. Blood is made up of several elements that all are very important and serve a particular function; a very important function of the blood is to transport hemoglobin. Hemoglobin is required to carry oxygen and carbon dioxide to the cells of the body. If blood is not circulating then the cells of the body are not receiving oxygen and carbon dioxide is not removed.

Since we only have so much blood in our bodies at a given time and the body requires constant pressures within circulatory system, the ability of the body to be able to constrict is critical (Guyton, 1982).

When a person goes into cardiac arrest, sudden changes in the cardiovascular system are seen. The first change is that the heart stops pumping blood to the body. Second, the circulatory system relaxes or dilates. Lastly, the blood cannot deliver precious oxygen to the cells.

When the heart stops pumping, instantly there is no flow into the heart from the venous side which causes no flow into the pulmonary system. When we have no blood flow into the pulmonary system then we have no return flow back into the left side of the heart and ultimately no flow out of the left ventricle.

Because the circulatory system dilates or relaxes, the pressure inside the system falls to zero. Zero pressure in the system means no coronary perfusion pressure and the heart has no blood supply. Additionally, the cells of the body shift into an-aerobic metabolism which was described earlier in this research paper (Huether & McCance, 2004).

Now that we have a general understanding of the cardiovascular or circulatory system, we should review the “P” in the CPR and review some general concepts of the pulmonary system or how we breathe. The responsibility of the lungs is for the process of ventilation, which is mechanical, and the act of perfusion which is the transfer of oxygen and carbon dioxide. There are a few mechanisms that are involved to facilitate the act of breathing, but the mechanical act of breathing involves the changes in atmospheric pressures from within the chest cavity.

When we inhale air into our lungs, we begin to create a change in the atmospheric pressures from within the lung as compared to outside the lung. On inhalation, the pressure inside the lungs increases as the lungs inflate with air. This is also referred to as increased thoracic pressure. As we begin to exhale, the weight of the ribs and thorax coupled with the change in the pressure facilitate the flow of air out of the lung. This is the mechanical process of ventilation.

The act of perfusion requires the movement of air down to the lowest part of our airway, the alveoli. These tiny grape like structures are rich in capillary blood flow. At the capillary level, oxygen easily diffuses across the capillary bed into the blood stream and carbon dioxide diffuses out of the blood. The act of perfusion ends when the oxygen reaches the target cells (Guyton, 1982).

Because the heart, the great vessels of the circulatory system, and the lungs share the same thoracic cavity, pressure changes within this cavity have a dramatic effect on other physiological processes of the body. As mentioned before, as we breathe we experience an increase in the pressures in the thoracic cavity. This pressure from the expanding lungs is exerted on the heart, the arteries, and veins having a squeeze like effect on them. The untoward effect of increased thoracic pressure secondary due to over ventilation is a decrease in the amount of blood flow back into the heart (Guyton, 1982).

The act of cardiac arrest is a massive insult to the body and survival decreases rapidly over a short few minutes. Evidence based medicine backed by outcome data clearly shows that CPR plays a critical role in survival from cardiac arrest, but how does CPR work?

In 1960, Dr. Kouwenhoven gave us the first glimpse as to how CPR works following his extensive research with dogs. Dr. Kouwenhoven believed because the heart is anchored between the heart and the sternum, it provided a perfect platform to manually provide flow in and out of the heart. Dr. Kouwenhoven believed the act of simply compressing the sternum would in fact compress the heart causing blood to be pushed out of the heart. On the upstroke of the chest compression, Dr. Kouwenhoven believed that the heart would naturally fill with blood (Kouwenhoven, Jude, & Guy, 1960).

In his experiments, Dr. Kouwenhoven induced ventricular fibrillation, ultimately cardiac arrest, in several dogs weighing between 11 and 52 lbs. Simple compressions of the chest, sometimes for up to thirty minutes, were performed with a single hand. Dr. Kouwenhoven observed that ventricular fibrillation during this time was maintained as long as compressions were being performed. At some point during the experiments, the dogs were defibrillated back into a normal heart rhythm (Kouwenhoven, Jude, & Guy, 1960).

Dr. Kouwenhoven also measured pressures within the dog’s circulatory system while compressions were being done. He measured blood flow in the carotid artery in the neck, and the instantaneous and average pressures in the femoral artery in the groin. Dr. Kouwenhoven observed that as compressions were being performed on the chest, the pressures in the neck and groin increased significantly. When compressions were stopped, the pressure in the arteries in the neck and groin would drop to zero (Kouwenhoven, Jude, & Guy, 1960).

Dr. Kouwenhoven discovered something else in his experiments that would be dismissed until many years later. He observed that the simple act of chest compressions alone provided some natural ventilation of the lungs. He argued that mouth to mouth ventilation was not needed (Kouwenhoven, Jude, & Guy, 1960).

In his JAMA article entitled Closed Chest Cardiac Message (1960), Dr. Kouwenhoven cites five cases of cardiac arrest where the victims were resuscitated utilizing two minutes of vigorous chest compressions and no mouth to mouth ventilation. Following the resuscitations, ventilatory support was provided as needed.

It is important to understand that a few short years before Dr. Kouwenhoven’s research began, the works of Dr. Elam and Dr. Safar had already been recognized and endorsed by the American Red Cross and the American Heart Association. As history shows, mouth to mouth ventilation has remained as an important part of CPR.

(3) What guidelines exist that define how cardiac arrest resuscitation efforts, including CPR, should be performed?

The American Heart Association is recognized nationally as a leader on the education of heart disease. They have been focused on studying, preventing and the education of the public on the topic of heart disease since the early 20th century. The American Heart Association was founded in 1924 by a group of physicians from New York, Boston, Philadelphia, Chicago, and St. Louis. Because there were many misconceptions about heart disease, the founding physicians knew that research into heart disease had to be studied and the information shared not only with the medical community, but the communities at large. Very quickly, the American Heart Association enjoyed rapid growth and began to expand their research into other areas. One of those was in the area of resuscitation (American Heart Association, 2010).

The American Heart Association has grown not only in scope and size of the organization, but also in their influence on standards of care. Today, the American Heart Association in conjunction with the International Liaison Committee on Resuscitation (ILCOR) establishes guidelines in the management of cardiopulmonary resuscitation, acute coronary syndromes including acute myocardial infarction, stroke, and other acute conditions (The American Heart Association, 2005).

The ILCOR committee was formed to review resuscitation science and make evidence based guidelines for resuscitation worldwide. The ILCOR committee established six task forces to continually review current evidence based practice. They are basic life support, advanced cardiac life support, acute coronary syndromes, pediatric life support, neonatal life support, and an educational task force (The American Heart Association, 2005).

Every five years, the American Heart Association makes changes to their guidelines based off of the ILCOR recommendations. Specifically looking at the guidelines for basic life support which includes CPR, the guidelines have changed significantly based on new evidence.

In Dr. Safar's book the ABC of Resuscitation, and ultimately adopted by the American Heart Association, the compression to ventilation ratio was 15 to two. That is, every fifteen compressions, you should ventilate the victim using mouth to mouth (or utilizing adjunct) two times allowing for the chest to rise and fall completely.

In the 2000 Guidelines for Resuscitation, and among many guideline changes, the American Heart revised their recommendation from 15 compressions to two ventilations to 30 compressions to two ventilations. Additionally, the American Heart Association recommended that CPR be performed for two minute intervals with the chest compressions being done at a rate of 100 compressions a minute and minimizing any disruptions to chest compressions. This change in the guidelines was a result of a better understanding of coronary perfusion pressure. Science showed that by the 15th compression, the coronary perfusion pressure was just becoming sufficient for feed the coronary arteries blood and then the compressions were stopped. When the compressions were stopped to allow for ventilations, the coronary perfusion pressure dropped to zero. By changing the compression to ventilation ratio to 30 to two, and by calling for 100 compressions a minute for a two minute interval, the coronary arteries were being perfused for a longer time (Advanced Cardiac Life Support, 2001).

In the 2005 guideline changes, the American Heart Association continued to emphasize the importance of not interrupting chest compressions while performing CPR. They made no real changes on the recommendations for CPR however did place an emphasis on very short pulse checks stating to take no more than five to ten seconds to check for a pulse (American Heart Association, 2006).

Most recently in the 2010 Guidelines, the American Heart Association made some significant changes that for the first time will deviate from the work of Dr. Safar. Historically, the emphasis has been from an ABC perspective that is the airway was always first, breathing (ventilation) was second, and circulation (compressions) was third (American Heart Association, 2010).

In November, 2010 at the Scientific Sessions in Chicago, the American Heart Association rolled out the new BLS guidelines. The priority is now “CAB” or circulation, airway, and then breathing. The emphasis is now on chest compression in a victim who suddenly collapses or is unresponsive and then airway and ventilation. In these changes, the pulse check has been removed for both the lay public and health care providers. According to the American Heart Association, it can be difficult to assess he presence of a pulse and too much time is spent not doing compressions while assessing for a pulse.

For the general public, the American Heart Association now recommends hands only CPR. In hands only CPR, the emphasis is on fast and hard chest compressions only with no airway or breathing assessment. It is their belief that if the public does not have to do mouth to mouth, and with the simple technique of chest compressions, more people will be more apt to perform CPR on a person in cardiac arrest.

The compression to ventilation ratio of 30 to two is still maintained however the rate per minute changed from 100 compressions a minute to at least 100 compressions a minute. The compression depth was changed from one to one half inch of compression depth to at least two inches of compression depth.

In the 2010 Guidelines, the American Heart Association provides a science overview as to the various phases of cardiac arrest to emphasize the importance of chest compressions and defibrillation priorities. As mentioned in the literature review section of this paper science has given us a better understanding as to what actually occurs the moment a person goes into cardiac arrest. There are three phases of cardiac arrest, the electrical phase, the circulatory phase, and the metabolic phase (American Heart Association, 2010).

The electrical phase begins the moment the heart stops and ends within four to six minutes of the cardiac arrest. Victims of cardiac arrest typically present in ventricular fibrillation in this phase and early defibrillation is the priority.

The second phase is the circulatory phase which begins at approximately four to six minutes and lasting through ten minutes. This phase has also been referred to as the perfusion phase and chest compressions are the priority. If defibrillation is performed in the circulatory phase, often times it is lethal (The American Heart Association, 2010).

The final phase is the metabolic phase. This phase begins approximately ten minutes after the heart has stopped pumping. According to the American Heart Association, prognosis for survival of a patient in this phase of cardiac arrest is poor (The American Heart Association, 2010).

Other changes and consideration include the recommendation to administer lower volumes of air when providing ventilations, citing the decrease of blood return to the heart often seen with over ventilation and the support to alternative techniques to resuscitation. The American Heart Association supports the concept of a new method of resuscitation known as cardiocerebral resuscitation where the focus is on high quality, uninterrupted chest compressions, and ventilation by positive pressure is discouraged (2010 guidelines).

(4) What other techniques or modifications are being used in the treatment of cardiac arrest?

As the American Heart Association provides some guidance in the delivery of positive pressure ventilation, that is to avoid over ventilation, other researchers have looked at ventilation from a different perspective asking the question is ventilations even necessary in a cardiac arrest victim.

According to Dr. NC Chandra of The Johns Hopkins Medical Institutions in Baltimore, Maryland, dog studies indicate when in cardiac arrest, chest compressions alone can maintain adequate oxygen saturations for several minutes. Dr. Chandra observed in his dog lab that with simple chest compressions and no ventilatory support, oxygen levels on the hemoglobin stayed above 90% for approximately four minutes. Chandra showed that after 14 minutes, the hemoglobin was still saturated with oxygen over 50% (Chandra et al., 1994).

Cardiocerebral resuscitation (CCR) is a resuscitation method that has been in practice in a few pre-hospital settings around the country. CCR deviates from the traditional focus of basic life support in that it focuses on high quality uninterrupted chest compressions with a de-emphasis on positive pressure ventilation.

In November 2003, the Sarver Heart Institute in Tucson, Arizona in cooperation with the Tucson Fire Department launched the first CCR protocol in the country. The CCR protocol for all cardiac arrest patients involved 200 uninterrupted chest compressions, single defibrillations rather than stacked shocks, pulse checks were eliminated, and the airway was managed with a simple oral airway and oxygen was administered by simple non-rebreather face mask. The outcome data from the new CCR protocol was staggering. The ROSC rate from primary ventricular fibrillation went from the average of 15% to 48% (Kellum, Kennedy, & Ewy, 2006).

In 2006, the City of Kansas City, Missouri implemented CCR as their treatment protocol for cardiac arrest. The CCR treatment protocol focused on high quality chest compressions where they administered 200 compressions in two minutes without stopping for ventilations. Following the 30^{th} compression, rescuers would provide a very low volume of air on the upstroke of the compression. Following the two minutes of chest compressions, a single defibrillation would be administered if the underlying arrest rhythm was ventricular fibrillation or pulseless ventricular tachycardia. Perhaps a more controversial change was the de-emphasis of endotracheal intubation. Paramedics often times would not intubate the patient during the resuscitation (Garza, Gratton, Salomone, Lindholm, McElroy, & Archer, 2009).

The City of Kansas City, Missouri reported that between April, 2006 and March, 2007, their ROSC rate jumped from 30.4% to 51.3% on primary ventricular fibrillation arrests. Their hospital to discharge alive jumped from 21.3% to 44.2% during that same time period (Garza, Gratton, Salomone, Lindholm, McElroy, & Archer, 2009).

In May, 2009, the study conducted by the City of Kansas City, Missouri was officially published in Circulation by the American Heart Association. In an editorial response to the Circulation, Dr. Gordon Ewy, a leading researcher in resuscitation from the University Of Arizona College Of Medicine asked the question do modifications of the American Heart Association guidelines improve survival of patients with out-of-hospital cardiac arrest. Comparing the results of the Kansas City, Missouri study with a similar study conducted by the Sarver Heart Institute, Dr. Ewy believed that certain modifications do increase the chance of survival following cardiac arrest (Ewy, 2009).

Post resuscitation therapeutic hypothermia is now recognized as a standard of care for post cardiac arrest patients who are resuscitated but show no signs purposeful movement. But the benefit of therapeutic hypothermia is now being evaluated in many of areas such as spinal cord trauma, traumatic brain injury, and stroke care. But one area that is showing significant promise is intra-cardiac arrest therapeutic hypothermia. This practice involves the cooling of patients while the resuscitation is being performed.

Experiences in France have demonstrated that the practice of intra-arrest hypothermia is not only safe and effective; it is easily implemented in the field. The University Of Caen, France and the Emergency Medical Services began rapidly infusing two liters of 4ºC intravenous fluids over 30 minutes along with high quality chest compressions. Thirty three patients were included in the study. Twenty of the 33 patients or 60.6% were resuscitated utilizing this protocol. It is important to point out that the patients enrolled in the study, only eight presented in ventricular fibrillation. The remaining 25 presented in Asystole and pulseless electrical activity as their initial rhythm. At six months, four patients survived to hospital discharge with no neurological impairment (Bruel et al., 2008).

In the article Resuscitation and Survival Rates from Out-Of-Hospital Cardiac Comprehensive Treatment Protocol, the Virginia Commonwealth University (VCU) Hospital boasts of their success with an aggressive intra-arrest hypothermia protocol. VCU in conjunction with the Richmond, Virginia Ambulance Authority (RAA) began cooling cardiac arrest patients beginning in 2004 through 2009. The treatment protocol is simple, high quality uninterrupted chest compressions, low volumes on ventilation, and the administration of 4ºC saline intravenously (Virginia Commonwealth University Hospital, 2009).

The VCU and RAA protocol increased the ROSC rate almost two fold according to the article. The ROSC rate jumped to 46 percent with the survival to hospital discharge increasing to 9.7% (Virginia Commonwealth University Hospital, 2009).

Dr. Michael Kurz, the Medical Director for the RAA stated the intra-arrest hypothermia in conjunction with high quality chest compressions is highly effective. In an interview with Dr. Kurz, intra-arrest hypothermia provides additional benefits other than the brain protection typically associated with hypothermia therapies. The administration of two liters of fluid improves vascular resistance, “By adding fluid to the container, it improves the quality of the CPR being delivered.” Another benefit of intra-arrest hypothermia are the effects on the heart. Dr. Kurz stated “in a mild hypothermic state, the heart responds better to defibrillation than does a warm heart.”

Discussion

Cardiopulmonary resuscitation has certainly evolved over time. It has evolved from a procedure that was performed by blowing warm air into the mouth and rectum using a bellow, rolling a person back and forth over a barrel, and trotting a horse up and down a beach allowing a cardiac arrest victim to bounce up and down, to current treatment of intra-arrest hypothermia and high quality chest compressions.

In my research for the writing of this paper, I could not help but to notice that the many of the changes and priorities actually go back to some of the work presented by other researchers many years ago, a sort of history repeats itself feeling.

Going back to the observations of Dr. Kouwenhoven and his question is ventilation really necessary in cardiac arrest, his research clearly showed the blood would stay saturated with oxygen for a longer period of time and that ventilations were not needed in the initial management of cardiac arrest patients. Dr. Kouwenhoven’s research on the vascular resistance effects of chest compressions clearly revealed two distinct benefits. First, the longer chest compressions were performed without interruption, the better the blood flow to the heart and second, ventricular fibrillation could be maintained for a longer period of time allowing time for a defibrillator to become available.

Thanks to the progress of medicine and science we have a better understanding as to how the various systems of the human body function physiologically and how in cardiac arrest, these bodily processes are affected in a devastating way. For a victim of cardiac arrest, coronary perfusion pressure is a key indicator of survival.

Coronary perfusion pressure is the pressure required to fill the coronary arteries to supply the heart with oxygenated blood. Since the coronary arteries get their pressure during diastole or relaxation, coronary perfusion pressure is directly related to the resting pressure in the vasculature. In cardiac arrest, we have no perfusion pressure so manual cardiac compressions are needed to create and sustain the arterial pressure to provide blood to the heart. Dr. Kouwenhoven illustrated this very well.

Positive pressure ventilation with mouth to mouth or other device has been shown to create a significant increase in thoracic pressure. As a result of this increase in pressure, we decrease the return blood flow back to the right side of the heart, thereby decreasing the cardiac output of the heart.

Another observation of Dr. Kouwenhoven was that chest compressions created natural ventilation. His research showed that when you compress the chest, air is forced out of the lungs. When the compression is lifted allowing the chest to recoil, air is drawn back into the lungs.

The research by Dr. Kouwenhoven has certainly contributed to the changes in resuscitation practices today. What he observed back in 1960 today is verified and supported with science.

Take cardiocerbral resuscitation for instance, the principles of this method of resuscitation clearly have a Dr. Kouwenhoven undertone. Cardiocerebral resuscitation as practiced emphasizes continuous cardiac compressions with very little interruptions. Ventilation management is not a priority in this method. Victims receive an oral airway which maintains the open airway and they receive oxygen which is delivered by a mask that is placed on their face. Notice no positive pressure ventilation and no endotracheal intubation. The focus is on CPR and defibrillation when indicated.

Outcome data is the truest litmus test for evidence based medicine. The outcome data reported by the City of Kansas City, Missouri and the Tucson, Arizona Fire Department clearly show an increase in out of hospital ROSC. Cardiocerebral resuscitation is even recognized as an alternative by the American Heart Association.

Other institutions have taken the principles of Cardiocerebral resuscitation to another level with the practice of intra-arrest hypothermia. The primary focus of this delivery method is still on high quality chest compressions with limited to no interruptions. Additionally, victims of cardiac arrest are receiving two liters of cold saline intravenously as well as ice packs placed at strategic locations on the body.

The science behind this resuscitation method makes sense. If you are adding fluid to a container that has dilated, you raise the pressure in that container. When you increase the pressure in the container by adding the fluid, you increase the effectiveness of the chest compressions. Additionally, hypothermia offers you two other advantages, it has been proven to protect the brain and second, the heart has been shown to defibrillate better in a hypothermic state.

Recommendations

Going back to my original problem statement, the practice of cardiopulmonary resuscitation among rescuers (at all levels) is fraught with inconsistencies caused by a gap between what are established standards of care, and what should be based on evidence based medicine and outcome data. Because of this, inconsistent treatment and inconsistent outcomes of patients in cardiopulmonary arrest are seen.

The purpose of this research project was been to explore the history and development of cardiopulmonary resuscitation and to provide a sound educational tool that will improve the uniformity of treatment, and provide practitioners with a sound foundation for the development of new techniques for adult patients experiencing cardiopulmonary resuscitation.

Throughout the United States, EMS agencies are attempting the resuscitation of cardiac arrest victims under a variety of different protocols that are governed by their medical directors. My experience has shown that many of the resuscitation protocols fall in line with the standards of care that are established by the American Heart Association.

EMS agencies historically are reactive by nature. We respond to calls for service, provide care, and transport to a medical facility. Our protocols are handed down to us by our medical directors who may or may not have experience in the delivery of emergency medicine and may or may not be engaged in continued research. We generally change our protocols when new standards of care come down the pipe. This should change. EMS agencies must challenge themselves to look for better alternatives to resuscitation (and medicine in general) that are based on solid outcome data.

The American Heart Association makes changes to the guidelines every five years. Five years is a very long time when other modalities are being used and are proving to be more effective; these are opportunities.

Other opportunities exist within our communities as well. With the American Heart Association emphasizing hands only CPR, EMS agencies should take the lead in developing hands only CPR classes for the communities they serve.

References

American Heart Association. (2001). *Advanced Cardiac Life Support.* United States of America: American Heart Association.

American Heart Association. (2006). *Advanced Cardiac Life Support.* United States of America: American Heart Association.

American Heart Association. (2010). *2010 Guidelines for CPR and ECC.* United States of America: American Heart Association.

American Heart Association (2010). *History of CPR.* Retrieved November 14, 2010, from American Heart Association Web site: http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/CPRFactsandStats/History-of-CPR_UCM_307549_Article.jsp

American Heart Association (2010). *Cardiopulmonary Resuscitation (CPR) Statistics.* Retrieved November 10, 2010, from American Heart Association Web site: http://www.americanheart.org/print-presenter.jhtml;jsessionid=HZP4FPL2SBZVYCQFC.jsp

American Heart Association (2010). *History of the American Heart Association.* Retrieved October 10, 2010, from American Heart Association Web site: http://www.americanheart.org/presenter.jhtml?identifier=10860

Bruel, C. M. (2008). Mild hypothermia during advanced cardiac life support: a preliminary study in out-of-hospital cardiac arrest. *Critical Care*.

Chandra et al.,(1994). Observations of ventilation during resuscitation in a canine model. *Circulation*, 3070-3075.

Cooper, J. A., MD, C. J., & Cooper, J. M. (2006). Cardiopulmonary Resuscitation. *Circulation*, 2839-2849.

Ewy, G. A. (2009). Do modifications of the American Heart Association guidelines improve survival of patients with out-of-hospital cardiac arrest? *Circulation*, 2542.

Garza, A. G., Gratton, M. C., Salomone, J. A., Lindholm, D., McElroy, J., & Archer, R. (2009). Improved patient survival using a modified resuscitation protocol for out-of-hospital cardiac arrest. *Circulation*.

Guyton, A. C. (1982). *Human physiology and mechanisms of disease.* Phildelphia: W.B. Saunders Company.

Huether, S. E., & McCance, K. L. (2004). *Understanding pathophysiology.* St. Louis: Mosby.

Kellum, M. J., Kennedy, K. W., & Ewy, G. A. (2006). Cardiocerebral resuscitation improves survival of patients with out-of-hospital cardiac arrest. *The American Journal of Medicine*, 335-340.

Kouwenhoven, W. B., Jude, J. R., & Guy, K. G. (1960). Closed Chest Cardiac Message. *JAMA*, 1064-1067.

Mayo Clinic (2010). *Sudden Cardiac Arrest.* Retrieved November 22, 2010, from Mayo Clinic Web Site: http://www.mayoclinic.com/health/sudden-cardiac-arrest/DS00764/DSECTION=causes

Mistovich, J. J., & Karren, K. J. (2010). *Prehospital emergency care* (9th ed.). New Jersey: Pearson Education.

Mitka, M. (2003). Peter J. Safar, MD "Father of CPR," Innovator, Teacher, Humanist. *American Medical Association (JAMA)*, 2485-2486.

Occupational Health & Safety (2010).*Report: Out-of-hospital cardiac arrest survival rate unchanged in 30 years. Retrieved November 15, 2010,* from Occupational Health & Safety Web site: http://ohsonline.com/articles/2009/12/05/report-outofhospital-cardiac-arrest-survival-rate-unchanged-in-30-years.aspx?sc_lang=en

Sands, R. P., & Bacon, D. R. (1998, April). An Inventive Mind: The Career of James O. Elam, M.D. *Anesthesiology*, pp. 1107-1112.

Texas Onsite CPR (2010). *The History of CPR.* Retrieved October 10, 2010, from Texan OnSite CPR Web site: http://texasonsitecpr.com/History.html

U.S Fire Administration (2008). Executive officer program, Operational policies and procedures. In *Executive fire officer program* (pp. II-2).Virginia Commonwealth University Hospital. (2009). *Resuscitation and survival rates from out-of-hospital cardiac arrest comprehensive treatment protocol.* Virginia Commonwealth University Hospital.